IMPROVED UTILIZATION OF WOOD AND WOOD FIBER

Panel Manager - Dr Michael Wolcott, Washington State University
Program Director - Mr. Jeffery L. Conrad

Improved wood utilization practices depend upon a continually advancing scientific foundation of basic research in wood properties and fundamental components of wood science. This program area supports research that addresses critical barriers to improved wood utilization and that will provide the scientific base from which new research and development can proceed. The major areas of focus include: (1) wood chemistry and biochemistry, (2) physical and mechanical properties of wood and basic wood processing technology, (3) structural wood engineering, and (4) forest engineering research. Innovative approaches to solving fundamental problems in the field of wood science and technology are encouraged.

2000-02373 Electrochemical Processing of Wood Fibers for Composites Applications

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Grant 2001-35504-10129, $83,686; 2 Years

The manufacture of composite forest products consumes 1.2 million metric tons of synthetic resins annually, accounting for over 50% of all phenolics and 70% of all amino resins. Although the petrochemical industry is currently experiencing a period of stable prices and availability, past history indicates the dramatic changes that may occur over a short period of time. Political and economic vagaries can result in either limited supplies of such materials or sharply higher prices. Indeed in 1994, phenol-formaldehyde resins experienced a 35% increase in selling price and the price of amino resins increased 100% (White 1995). Furthermore, competition for these commodity chemicals is developing from agricultural demands for urea and plastics from phenol.

In an effort to circumvent the uncertainties associated with synthetic adhesives, methods have been reported by which oxidized wood surfaces may participate in autoadhesion, obviating the need for synthetic resins. To date, oxidative processes have been chemical or enzymatic and are predicated on the removal of electrons from lignin, generating free radicals on each surface that subsequently couple, forming a chemical bond. While enzymatic oxidations have recently been reported to be feasible (Felby et al. 1997), enzymes can be sensitive to work with and are dependent on fungal cultivation and growth.

As an alternative, the current proposal describes two electrochemical methods. Electrochemical oxidations can be broadly divided into two large groups, relying on either an external source of electricity (electrolytic processes) or chemical energy (volatic processes), for the removal of electrons from fiber surfaces.

2000-02482 Tests and Analysis of Layered Wood-Concrete Beams, Floors and Decks

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Grant 2001-35504-10043; $110,000; 2 Years

A solid reinforced concrete slab floor is highly wasteful of materials. Low strength of plain concrete is the reason for placing steel reinforcement in the bottom of a slab. That zone cracks and is ineffective in providing member strength and stiffness. Thus, about half of the slab depth serves only to hold the steel in place. The intent of the research is to demonstrate that the wasted concrete and expensive steel can be replaced by a structurally effective, lower cost solid wood layer. Since wood is already used as formwork for a solid slab, the gain is to instead leave it in place, reduce the concrete slab thickness by about 50% and interconnect them. This replaces concrete and steel with a managed renewable resource. The goal is to achieve high structural efficiency and durability using small size wood members that are essentially free as they are used for shoring anyway. Besides wise application of the forest resource, other advantages are savings in energy of production and construction, improved fire resistance and protection of the wood layer from moisture. The focus is on long-term durability of the system. Layered wood-concrete beam and connection specimens will be subjected to extreme conditions of humidity. These will be load tested under long-term loading and cyclic (repeated) loading. A full-size deck will be subject to static loading and then "load conditioned" by a sequence of cyclic loadings and long-term load tests.

2000-02372 Affect of Vertical Load on the Lateral Load Capacity of Wood Frame Shear Walls

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Grant 2001-35103-09934; $95,429; 2 Years

Wood frame structures are highly redundant systems that rely on many components, working together, to resist the dynamic forces of hurricanes and earthquakes. Although each component has an important role to play, the wood frame shear wall is the backbone of the lateral load resisting system and is crucial to the integrity of the entire structure. It not only carries vertical load, but must also resist the lateral forces due to wind and earthquakes.

The objective of the research is to study the affect of vertical load on the cyclic lateral load response of wood frame shear walls. A program of testing and numerical modeling is proposed. Full scale shear walls will be tested under combined vertical and cyclic lateral load. The effect of vertical load on the ultimate strength and energy dissipation capacity of the wall will be established. Cyclic tests will also be conducted of typical nailed connections in which the stud is in compression. The purpose of these tests is to establish if the strength of the connection is dependent on the magnitude of the compressive stress (i.e., vertical load) in the stud. Finally, a numerical model of the shear wall will be developed to accurately predict the complex behavior of wood frame shear walls under varying vertical loads. Once calibrated using the full scale test results, analyses will be conducted of other shear wall designs. Through a combination of testing and modeling, adjustment factors for the effect of vertical load will be determined for sixteen different code specified shear wall configurations. The research proposed will lead to a better understanding of the behavior of wood frame shear walls under combined cyclic lateral and vertical loads. This will lead to a better utilization of materials and more cost effective designs.

2000-02167 Design and Prototype Development of a Computer Vision-based Lumber Production Planning System

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Grant 2001-35103-10049; $190,000; 3 Years

The proposed project aims to address key issues pertaining to the design and prototype development of a Computer Vision-based Lumber Production Planning System (CVLPPS). CVLPPS is a sequel to an earlier research project funded by the USDA NRICGP which resulted in the design and development of a computer vision-based system called CATALOG. CATALOG is capable of identification and localization of important internal defects in hardwood logs via computer analysis of cross-sectional CT images, 3-D reconstruction and visualization of the internal structure of the hardwood logs, and interactive graphical simulation of typical machining operations on the reconstructed 3-D log models. CVLPPS will enhance CATALOG by the design and implementation of computer algorithms that would exploit the knowledge of the 3-D structures and locations of the internal defects in the hardwood log to determine a set of lumber processing strategies that would optimize the grade and yield of the resulting lumber. These algorithms will be parallelized on a network of workstations with a goal of attaining real-time performance in a typical saw milling scenario. The successful completion of the proposed project will be a major step in improving the sustainability and conservation of valuable hardwood forest resources in the United States. It will promote environmentally responsible utilization of forest resources by improving lumber processing efficiency and reducing wastage. The resulting technology will add value to the products derived from scarce hardwood resources thereby improving the profitability of the hardwood lumber manufacturing industry and uplifting rural economies that depend on efficient utilization of forest resources.

2000-02377 Development of a Small Autonomous Log Skidder

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Strengthening Award; Grant 2001-35103-10047; $150,000; 3 years

It is proposed to develop an autonomous forest robot. This robot would be capable of dragging logs over a primitive trail with little supervision by a human operator. The robot would operate with a considerable degree of autonomy, provided by a new type of “embedded knowledge" fuzzy logic controller. Use of an autonomous robot coupled with new harvesting practices would open doors for the timber industry, while minimizing impacts on the environment. Funds provided by this program will be used to fabricate a third generation version of the forest robot, and to design an embedded knowledge fuzzy logic controller appropriate for dragging logs through the forest over a primitive trail. The mechanical design of the skidder robot capitalizes upon experience gained from testing two previous versions of the vehicle in the forest environment. The control system, whose theoretical framework has already been determined, is now being prototyped on a mobile instrument platform. Sensors from this platform will be directly transferred to the autonomous forest robot. The controller will be further adapted to the autonomous forest robot. The environmental impact and economic viability of the autonomous robotic log

skidder will be assessed in a limited test program conducted in the University of Idaho Experimental Forest.

2000-02385 Determination of the Mechano-Sorptive Properties of Wood on Material Level

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Grant 2001-35103-10048; $113,500; 2 Years.

One of the most important aspects of the mechanical performance and durability of wooden and wood composite elements used in structures is their response to varying climate conditions over their service life. Development of improved design procedures and more efficient use of wood in structural applications requires improved information about the influence of changing relative humidity and temperature on the expected long-term (over 100 years) structural response of these materials.

Even though the problem has been studied extensively for more than five decades now, there are still no mathematical models available to consistently describe the long-term mechanical performance of wood as function of moisture and load history. One of the key conditions to achieve this goal is understanding and modeling of the mechno-sorptive behavior of wood, which is the response of wood to load under moisture content variation. There is however, no standard method to determine the mechano-sorptive properties of wood. The existing data are scattered throughout the literature, cover only a few wood species and, in most cases, cannot be generalized to specimen dimensions and climate conditions different from those used in the original experiments.

The objective of this project is to provide a simple, reliable, systematic and repeatable method to determine the basic hygro-mechanical properties of wood. The method will enable initiation of a database covering mechano-sorptive properties of species most commonly used in structural applications and will be essential to improving the performance of rapidly emerging composite wood materials.

2000-02346 Wood Modification by Brown Rot Fungi

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Strengthening Award; Grant 2001-35103-09935; $176,000; 2 Years

Understanding the basic mechanisms involved in the biodegradation of wood by microorganisms has implications for the development of appropriate methods of protection for wood and wood products. Decay and discoloration caused by fungi are major sources of loss in both timber production and wood use, causing loss in standing timber of 15-25% marketable wood volume and in wood products of 10 -15% during storage and conversion. It has been estimated that 10% of the annual forest cut goes toward replacement of degraded wood timbers. An enhanced knowledge of the mechanisms involved in microbial degradation of lignocellulose will potentially allow us to better manage wood degradation and bioconversion.

Brown rot fungi are the major group of organisms associated with degradation of in-service wood. Biodegradation of wood and wood fibers is of interest both because of

the need for decay prevention in wood products and because of potential biotechnological applications. Fundamental information on the biological and chemical processes involved in brown rot modification of wood is lacking. The proposed work focuses on the chemical changes occurring in the wood during biodegradation and when treated with a cell free system. We hope an enhanced understanding of the chemical changes associated with brown rot degradation along with the fate of non-enzymatic agents such as biochelators and oxalate putatively involved in the process will ultimately lead to a greater ability to control biodegradation in wood products.

2000-02359 Corrugated Wood Composite Panels for Structural Decking

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Grant 2001-35504-10042; $118,500; 2 Years

The goal of this project is to improve upon current flat panel products by developing a shallow corrugated panel that could require only minor changes to current manufacturing and construction methods. The corrugated panel plus an underlayment sheet will be about the same weight as current single or double layer floor sheathing systems and to span from 32 to 48 inches with improved strength and stiffness. Design studies using computer models will identify the most promising corrugated panel configuration based on structural performance and compatibility with construction practices. Molding trials on small specimens with candidate corrugation patterns and thicknesses will provide data for full size molding dies and allow testing of localized structural properties. Production of a minimum of thirty-four full sized, 48"x 96" corrugated panels will follow. Panel testing will be done to simulate floor loading during construction, without a top underlayment layer, and during occupancy, with an underlayment over the panel. These tests will be designed to simulate actual load conditions and construction details. A limited number of specimens will be subjected to long term loading to evaluate creep deflection characteristics. A mock up floor system will be constructed and tested for deflection, vibration, and overall system behavior. Composite action specimens will be tested for load sharing between the corrugated deck system and the supporting joist. The results of the project should provide a clear indication of whether corrugated panels are a concept worthy of further development by the forest products community.

2000-02171 Genomics of Heartwood Formation

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Grant 2001-35504-10040; $125,000; 2 Years

Most commercially important tree crops produce heartwood, the “dead” central core of the woody axis. The presence of heartwood is the major determining factor for wood quality and influences the way in which specific woods are utilized. Understanding the molecular mechanisms of heartwood formation is of great commercial and keen scientific interest. Despite the long history of study on wood formation, our knowledge of this unique biological process is limited, mainly due to the experimental difficulties of observing the complex processes inside tree trunks. Furthermore, comparative molecular

genetic studies have limited use because most model organisms do not undergo secondary woody growth. We propose to attack this tree-specific problem by studying the genes expressed during the transition from sapwood to heartwood. Specific objectives are to produce large numbers of expressed sequence tags from the sapwood-heartwood transition zone and to identify candidate genes for their involvement in heartwood formation.

This award will support our effort to understand the molecular mechanisms of heartwood formation, to identify genes specifically involved in the process, and to make use of the knowledge for the purpose of producing value-added wood products. The database of expressed genes generated by this research will enable the detailed analysis of the role of specific genes in heartwood formation. The genes identified will become the focus of tree improvement strategies for production of value-added wood products. Therefore, this award will lead to a technology that unlocks the bottlenecks in wood utilization, exploits maximum productivity, and extends the lifetime of wood products.

2000-02388 Stabilization of Cellulose Solution in N-Methylmorpholine-N-oxide

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Grant 2001-35504-10130; $90,000; 2 Years

The growth of world population along with increasing textile consumption per capita is causing greater emphasis to be placed on utilization of renewable biomass for production of textile fibers. It has been estimated that in 2002, approximately 75 million tons of textile fibers will be needed, of which 45-55% or 30-41 million tons will be cellulose fibers, mostly cotton. Among the cellulose fibers, only 1.9-2 million tons is derived from dissolving pulps. Moreover, if the consumption for textile fibers grows at the same rate as in past 10 years, the world production of cellulose-based fibers must increased by at least 50% in the next 25 years. This increase cannot be covered only by an increase in cotton production because the growth in the production of cotton is limited by capability of the genetic improvement of plants of the genus *Gossypum* in terms of cotton yield as well as by geographic factors and cost effectiveness. Consequently, wood cellulose fibers must be used for manufacture of textiles to cover the deficiency in the cotton-based textiles to satisfy the increase in demand for cellulose based textiles. The objective of this research project is to explore reactions involving thermal decomposition of both cellulose and N-methylmorpholine-N-oxide in the cellulose solution in N--methylmorpholine-N-oxide to minimize the decomposition. This may lead to development of new N-methylmorpholine-N-oxide technology for the manufacture of textiles from renewable wood cellulose resources and greater cost-effectiveness of the technology.

2000-02476 Cellulolysis - Fundamental Understanding of End-Product Inhibition

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Grant 2001-35504-10158; $97,500; 2 Years

Paper, wood products and timber together form a flourishing industry. However, as these woody materials are subject to decay by wood rots, such degradation presents a continuing major economic problem. The destructive microbes lurk in every crook and cranny awaiting opportune conditions to effect their deleterious actions. Dampness alone, often triggers them. This project addresses means to determine the structure of enzymes of decay microbes that attack wood, the component enzymes being glucosidases. Focus will be on gaining structural information by study of how natural sugars, when present in high concentration, inhibit the action of these wood degrading enzymes. Through consideration of these natural inhibitors, their effects on the active site and mechanism of action of the enzymes will be obtained. With such data at hand, this will facilitate rational design of more effective inhibitors. The overview is to obtain fundamental data on enzyme structure and function which will permit the preparation of novel inhibitors, leading to the goal of reducing the rots that at present cause major loss to the timber and paper industry.

2000-02342 Moisture Transport in Paper Under Varying Humidity

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Grant 2001-35103-10148; $150,000; 3 Years

This proposal is concerned with moisture transport in paper under steady state and dynamic relative humidity (RH) conditions common in paper testing laboratories. The moisture content of paper has a profound effect on its mechanical and electrical properties. There is a severe loss in the strength properties of paper with increasing moisture content that is accentuated under cyclic RH. In contrast to the considerable amount of work done on the influence of moisture on the mechanical properties of paper, the area of moisture transport in paper, which TAPPI in 1996 designated as one of the top twelve research needs in the pulp and paper field, is only beginning to receive attention.

We propose detailed experimental and theoretical investigations of moisture transport in paper under both steady state and dynamic RH. Moisture-transport mechanisms in paper will be investigated under steady state RH conditions in a diffusion cup apparatus. The transport coefficients obtained from the steady-state work will then form the basis to investigate the uptake and release of moisture by paper under step, ramp and cyclic changes in RH of the external environment.

The outcome of this research will be a coherent body of knowledge about moisture-transport mechanisms in paper under steady state and dynamic RH conditions. It will be applicable in understanding accelerated creep, warp and dimensional stability of paperboard under changing RH (thereby leading to better design of packaging materials), image deletions in copiers, and drying of wood and paper (an energy intensive process), thus, leading to their better utilization.

2000-02481 Use of Ionic Liquids for the Chemical Production of Higher Value Lignin Products

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Grant 2001-35103-10146; $170,117; 2 Years

Lignin represents an immense and renewable resource for the production of a great variety of chemicals and chemical products, if only we could understand and control its chemistry. Recently a new technology has been developed called room temperature ionic liquids (RTIL's). These are solvents that have both organic and inorganic properties. Like inorganic compounds, they are composed of cations and anions and have no vapor pressure, yet like organic solvents, they are liquid at or near room temperature and are powerful solvents for a great variety of organic compounds. RTIL's hold the potential for entirely new kinds of chemistries and separations for organic compounds such as lignin. This new technology has not yet been applied to lignin chemistry. This proposal does that by investigating oxidation chemistry for lignin fractions and model compounds in RTIL's.

With many catalysts, RTIL's, and different lignin-based compounds to study, we will develop a combinatorial technique to rapidly scan a multitude of reaction systems in a minimum of time. The wood science community needs more and better tools to deal with lignin. The development of this combinatorial approach will constitute a major advance in lignin chemistry techniques. This project will take a significant step forward toward the goal of realizing the full potential of lignin as a chemical resource.

2000-02347 Investigation of the Mechanisms by which the White-rot Fungus *P. cinnabarinus* Uses Laccase to Degrade Lignin

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New Investigator Award; Grant 2001-35103-10149; $120,000; 2 Years

Degradation of wood by fungi in the forest is one of the key processes in the global carbon cycle. White-rot fungi are the only microorganisms that are able to efficiently degrade one of the major wood components, lignin. It has been demonstrated that laccase, an oxidative enzyme excreted by a fungus, is essential for fungal degradation of lignin. This study aims to provide a better understanding of how the fungus *Pycnoporus cinnabarinus* uses laccase for the degradation of lignin. The investigation will focus the following issues: (1) to investigate whether a laccase-mediator is needed for the fungus to degrade lignin, (2) to investigate whether compounds with the same characteristic chemical structures as some natural products could be effective laccase-mediators for pulp bleaching, and (3) to investigate whether the fungus also produces an organic compound that enables laccase to effectively degrade lignin.

As we know, production of white paper, a process for selective removal of lignin from wood, requires harsh conditions and may result in environmental pollution under certain conditions. Since fungal degradation of lignin is an efficient and environmentally safe process, results from this research are expected to have great impacts on the development of an environmentally benign pulp bleaching technique and on our understanding of biodegradation of lignin in nature.

2000-02273 Predicting Individual Change Behavior at Forest Products Producers

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Grant 2001-35504-10164; $98,000; 2 Years

Wood products manufacturers are being forced to change in order to meet ever-changing demands from their competitive environments. However, change at an individual level must occur in order for the organization as a whole to change. The overall objective of this project is to increase our understanding of the factors that influence desired change-related behaviors of individuals employed by wood products producers, and how those behaviors can impact mill performance. Specific objectives include investigating the impacts on desired change behaviors of: (1) type and source of information received, (2) modes of communication used, and (3) individual employee characteristics (e.g., motivation, attitudes, satisfaction, beliefs, etc.). Additional objectives include an examination of organizational variables such as culture and climate and how they impact change behavior. Archival data from production facilities will be used to test for correlations between change adoption and performance measures. Employees at multiple primary wood processing facilities will be surveyed in order to test our hypotheses. Interviews will also be conducted with key personnel to determine which change behaviors are most critical to their success. Results can be used by managers to more effectively predict and encourage adoption of desired behaviors, and in turn increase mill efficiency and profitability. Implications for managers will have direct relevance to the long-range competitiveness of U.S. producers and the more efficient use of wood fiber.

2000-02366 Wood Species Dependence of Isocyanate Cure Chemistry

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Grant 2001-35103-10163; $155,000; 2 Years 6 Months

This project is designed to reveal new information about the cure chemistry of polymeric isocyanate adhesives that are used to make wood-based composites. Isocyanate adhesives are gaining market share because of their superior performance. Why isocyanate adhesives are superior is not currently understood. We hope to shed some light on this by employing a novel method of chemical labeling using two complimentary isotopes; nitrogen-15, and carbon-13. These are "magnetic isotopes" which allows one to observe the chemical environment near the labeled atoms using nuclear magnetic resonance in the solid state. The doubly labeled resin will allow us to probe fine details about the cure chemistry of this system, details that have not previously been accessible with other methods. Additionally, we will determine if different wood species have an impact on the cure chemistry. We suspect that the cure chemistry may be species dependent because the performance of polymeric isocyanate resins is highly dependent upon the type of wood. Finally, we will determine how simulated weathering affects the cure chemistry of this system. This is important because adhesive durability will have a huge impact on the quality of wood-based composites. In summary, this is a fundamental study of wood-isocyanate cure chemistry with the expectation that it may allow for the improvement of future wood-based composite materials.

2000-02468 Investigation of Capacity Design for Bolted and Nailed Connections

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Grant 2001-35504-10131; $70,000; 2 Years

The three objectives of this study are: (1) to experimentally determine the ultimate capacity of nailed and bolted single shear connections; (2) to develop the modifications necessary to use the yield theory for capacity design of bolted and nailed connections, and (3) quantify the differences between the current 5% offset yield and capacity values for the yield modes currently used in the LRFD specification.

This project will benefit the design community by providing needed data on the ultimate capacity of single shear dowel-type connections. It will provide an increased empirical data set for use in calibrating and validating design codes such as the LRFD specification and allow the method to become a true strength design procedure. A hypothesis of the project is that the Yield Theory can be modified so that the ultimate capacity of a joint can be predicted if the ultimate dowel-bearing capacity and other mechanical properties are used as input data to the theoretical models. The scope of the investigation will be single-shear connections since they are by far the most prevalent connections in wood construction.

2000-02374 Sixth International Conference on Woodfiber-Plastic Composites

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Conference Grant; Grant 2001-35103-10050; $8,000; 1 Year

Incorporating wood or other natural fibers into plastics results in a composite with different properties than those of either wood or plastic alone. Woodfiber-plastic composites have advantages such as good stiffness, low moisture absorption, and low cost. Both research and industrial activity have grown dramatically in recent years. To facilitate discussion on advances in this technology, the Forest Products Laboratory in cooperation with the University of Wisconsin-Madison, the University of Toronto, and the Forest Products Society hosts conferences on woodfiber-plastic conferences.

The 6th International Woodfiber-Plastics Conference will be held in Madison, Wisconsin, May 15-16, 2001. The conference serves to expand the understanding of composites made from virgin and recycled plastics and various wood residues or agricultural fibers. The conference brings together people from both academia and industry since the papers and posters presented include issues relevant to fundamental and applied research and commercial applications. The last conference, held in May 1999, had 325 registrants with academic and industrial representatives from 17 foreign countries.

In addition to the conference, an optional workshop will be offered on May 14th as an introduction to woodfiber-plastic composites. Surveys at past conferences have identified a need for such a workshop. Due to the varied backgrounds of attendees, some education on the various aspects of woodfiber-plastic composite technology is necessary for many of the attendees to participate fully in the conference.

2000-02344 Wood Fiber Suspension Processing via Fiber-level Simulations

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Grant 2001-35103-09933; $125,000; 2 Years.

Processes that utilize wood fibers typically involve suspending the fibers in water and exposing the suspensions to various types of flows. Such processes are limited by entanglement and aggregation of the fibers, which restricts the fiber concentration, requires the addition of a variety of chemicals to facilitate suspension flow, and in general limits the utilization of wood fiber. Improving fiber utilization requires overcoming these limitations. This can be accomplished by understanding the behavior of flexible fibers in flow, and specifically, understanding the effects of fiber properties and interactions on the behavior of fiber suspensions. In this research project, we will address these challenges by developing fiber-level computer simulations of wood fiber suspensions in various flows and specific applications. The ultimate goals of this work are to understand the behavior of fiber suspensions, to improve fiber processing, and to increase the utilization of wood fibers. Fibers are modeled as rigid rods linked by elastic hinges to model real, flexible fibers. The computer simulations determine the motion of each individual fiber, while taking into account the effects of the surrounding liquid, as well as various interactions between fibers. Specific objectives of this research are (1) to determine the effects of different fiber properties and interactions on their flow behavior, (2) to simulate the formation of a sheet of paper (a handsheet), and (3) to determine the effects of process variables on such sheet properties as strength and stiffness.

2000-02384 Interactive Cellulosic Materials for the New Millennium

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Grant 2001-35103-10109; $167,500; 3 Years

We plan to develop a whole new line of interactive materials based on natural cellulose products. For example smart paper packaging would indicate effects of shock, temperature and moisture in shipping, smart wallpaper could signal sickness syndromes in hospital rooms. Cellulosics could be made electrically conductive for applications in micro-sensors and electronic circuits. Thermal coloring and photo-erasing of paper are also potentially realizable. Additional applications include molecular recognition and molecular manufacturing systems developed from immobilized biomolecules such as enzymes and oligonucleotides on cellulosics for advanced future technologies and medicine. This will be accomplished through treatment of the cellulosic materials with plasma gases which are electrically activated gases discharged in a vacuum, similar to fluorescent lights. The active gases modify the surface of the cellulose without altering the base structure. Use of different gases and reaction conditions allow different types of products to be produced. It is expected that traditional uses of cellulosic materials will also be greatly enhanced with new technology. The work will involve both a static reactor and a totally newly designed and constructed, variable pressure continuous plasma reactor for modification of cellulose sheets, films and nonwoven fabrics. Improved reactivity to inks and surface coatings, improved resistance to liquids and vapors, improved adhesive release properties and specialized filtration properties can be realized with this approach. Additional goals are production of interactive cellulosic

materials by imparting electrical conducting properties and modification for use in molecular recognition applications. We plan to immobilize enzymes on cellulosic substrates as well as create oligonucleotide libraries for advanced technological applications.

2000-02350 Earlywood and Latewood Properties in Loblolly Pine Plantation Wood

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Grant 2001-35103-10178; $118,440; 2 Years

For simplicity in design, wood is characterized as homogeneous in a manner similar to metals. Yet, even small children have observed the inhomogeniety of wood when they count the earlywood-latewood tree rings in a log. Wood is not homogeneous and this research proposes that to assume so is an oversimplification that is often detrimental to the best utilization of the resource. This research will characterize for the first time, the mechanical properties of individual earlywood and latewood layers in logs from a Southern Pine plantation. Wood products from rapidly grown plantation trees often possess only a few growth rings. Thus the individual properties of the earlywood and latewood are believed to play a role in vexing unexplained poor performance characteristics in stiffness and dimensional stability in some Southern Pine plantation wood products. These problems limit the use and value of products derived from this wood. Similar problems exist with rapidly grown hemlock in the western United States. In this research, we will obtain logs from a Southern Pine plantation, fabricate small test specimens from the individual earlywood and latewood layers, and conduct a variety of tests to determine the engineering properties and dimensional stability characteristics of the earlywood and latewood specimens. Establishment of these properties as a function of growth ring, orientation and height in the tree will be the first step in research that will enable wood products to be designed and produced in way that accounts for the inhomogeniety caused by earlywood and latewood.